LOCOMOTIVES!

Past and Present

Leonor F. Loree

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An Address Delivered
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By

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THE NEWCOMEN SOCIETY OF ENGLAND

THE Newcomen Society of England was established at London shortly after the World War, in order to encourage and promote the study of the history of Engineering and Technology. From its inception, the Society has been in close touch with The Stiente Museum at South Kensington, which has served as the London headquarters of the Society. Its British membership includes many names of engineers, physicists and technologists distinguished for their services in various parts of the British Empire. There are many foreign members.

The Society takes its name from Thomas Newcomen (1663-1729), the British engineers, whose distinguished contributions in improvements to the newly invented steam engine brought him lasting fame in the field of the mechanic arts.

The "Transactions" of the Society, issued annually at London, constitute an unique and most valuable contribution to the history of Engineering. These annual volumes find their way to the libraries of engineering and technical universities and institutions virtually throughout the world.

In 1923, through the efforts of a small group of well-known American engineers and technologists headed by Mr. L. F. Loree, there was established the American Branch of The Newcomen Society. The Honorary Corresponding Secretary for North America maintains his office at the headquarters of The American Society of Mechanical Enginners at New York. Two American engineers are serving on the Council at London, and one of them is a Vice-President of the Society.

Annual Dinners are held simultaneously at London and New York, and cable greetings exchanged. The papers presented at these Annual Dinners are read simultaneously at London and New York.

The Newcomen Society of England enjoys international reputation in the value of its papers and meetings, which are based upon exhaustive historical research on the part of distinguished engineers, executives and technologists.

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"The Stourbridge Lion" — 1829
From the painting in the President's office of the Delaware and Hudson Railroad Corporation, at New York

NOTWITHSTANDING man's age-long acquaintance with the atmosphere, it was only at the close of the fifteenth century that it was recognized that the air had weight, and similarly, notwithstanding his age-long acquaintance with steam through observing its discharge from boiling water, he had before the eighteenth century found no means of utilizing its force. In 1712, Newcomen successfully used the condensation of steam to produce a vacuum by means

of which he was able with the atmospheric pressure to operate pumping engines in mines. Utilization of the expansive force of steam was the product of the genius of James Watt, who patented his double-acting steam engine in 1782, and applied the force thus generated to a rotary motion in 1784.

Land carriage in England at that time was carried on almost exclusively by pack horses, which might transport 224 pounds at the rate of 25 miles per day over an average level country. At the coal mines at Newcastle-on-Tyne, this movement had been improved by the introduction at the very beginning of the seventeenth century of wooden rails, so that the load for the horse was increased to 4,704 pounds, and when iron plates, or straps, were imposed upon the wooden rails, the load was increased to 5,936 pounds, exclusive of the weight of the wagons.

About 1767, iron rails were substituted for the wooden rails with their iron plates, enabling the load to be increased to 9,400 pounds.

The introduction of the steam locomotive as an instrument of transportation was spread over a long period of nearly a quarter of a century. The first was operated by Richard Trevithick on Christmas Eve, in 1801. Hedley, in 1813, first proved by his experiments that the adhesion of the wheels upon the flat rails is sufficient to give motion on a level or slightly ascending track. The final supremacy of this method of transportation was established on October 6, 1829, by George Stephenson's engine, the "Rocket," in the competitive trials at Rainhill on the Liverpool and Manchester Railway. This engine was four-wheeled, not coupled, and weighed a little

less than four and a half tons. Stephenson figured that from 10 to 12 pounds tractive effort would be required to move one long ton, so that, assuming that one-half of the total weight of the "Rocket" was on the two drivers, the engine would have a hauling capacity of 102 long tons.

The ability of the locomotive to move under the application of the force of steam results from the adhesion of its wheels to the rails. It is seldom realized how small is the area of contact which, upon the large modern locomotive, is for each wheel about one-third of a square inch, a space about as large as one's thumb-nail.

The adhesion of the smooth surfaces of the wheels and rails in these very small areas is dependent upon weight alone. The adhesion is diminished by the effect of the torque, due to the alternate working of the two cylinders; to the reciprocating motion imparted by the piston movement; to irregular handling of reverse gear and throttle by the enginemen, and by the condition of the rail. About one-quarter only of the weight on the drivers can be relied upon to secure "tractive effort."

The power of a locomotive is measured in "horse power." For this purpose, the power of a horse is taken at 33,000 pounds raised one foot in one minute. This "horse power" is a purely arbitrary unit. It is supposed to represent the average power of a horse working over a considerable period. The real power of a horse has been determined at about three-quarters of the "horse power" assumed as the measurement of the working rate. The power of the six and one-half ton engine, the "Stourbridge Lion," the first to be operated in the United States and

put into service on the Delaware and Hudson in 1829, was figured as equal to forty-one and one-half horses. Its indicated horsepower was 6.5 at three miles per hour. The latest engine built by The Delaware and Hudson Corporation, and in service, is the "James Archbald," developing 572 indicated horse power at three miles per hour, or 88 times that of the early engine. The maximum horse power performance of the "Stourbridge Lion" has been calculated at 11 horse power at a speed of five miles an hour; the maximum horse power performance of the "James Archbald" is 3,207 horse power at a speed of 35 miles an hour, the capacity of the latter over the former representing an increase of 291 times. A later locomotive, 1403, working under a triple expansive of the steam, has just been received from the American Locomotive Company, but no service data are as yet available.

The "James Archbald," our latest development in operation, carrying 500 pounds steam pressure and weighing 300,000 pounds upon its four pairs of coupled driving wheels, exerts a tractive effort upon a level road of 75,000 pounds, or the equal (assuming a revenue tonnage of 10,920 is carried in 156 fully loaded 70-ton capacity cars weighing 4,080 tons on a straight level track at a speed of 15.6 miles per hour) of 97,500 pack horses.

The gross weight of the engine, tender, cars and lading gives a ratio of pay load to dead weight of 250 to 100, while in the case of the pack horse the ratio was 20 to 100, an advantage in favor of the locomotive of 12.5 times.

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*The "L. F. Loree"—illustrated at back of this reprint. This locomotive exhibited at the "Century of progress", Chicago.

The speed of the modern engine, 15.6 miles per hour, which is the average for the Class I roads of the country as against 3 miles per hour for the packhorse is 5.2 times as fast.

As against the pack horse, our speed has increased by 5.2 times. Our ratio of pay load to dead weight has improved 12.5 times, while we have one instrument of transportation, the locomotive, doing the work of 97,500 instruments of transportation, the pack horses.

After the successful trial of the "Rocket" in 1829, great improvements were made in the years immediately following. The cylinders were placed horizontal; the firebox was built integral with the boiler; the tender was changed from a truck and barrel to the present type; the smoke box was added; but the outstanding improvement was securing, in 1839, an exhaust clearance by a lap in the valves, reducing the back cylinder pressure and increasing the use of the expansive properties of the steam. The improvement in the use of coke in gross tons (2,240 lbs.) per train miles was:

	Pounds
The old valves – no lap	49
Improved service by encouraging competition among the crews	40
Valves with 3/8 inch lap	36
Valves with 3/4 inch lap	32
One-inch lap, old passages	28
Same with increased care in firing	22
New locomotive, one-inch lap, enlarged passages, etc.	15

This reduction of about 70 per cent in the fuel consumed in the performance of the same work is one of the most remarkable

incidents in locomotive history. Following this approximately ten-year period of rapid improvements, changes were introduced from time to time, with long intervening periods of quietude. The most significant were: fire-box baffle walls; the compound engine, at first impracticable with the saturated steam, but now again coming into use with the comparatively dry steam created by superheating; the articulated engine of Fairlie, further improved by Mallet, for narrow-gauge practice, which I developed for standard-gauge practice and introduced on the Baltimore and Ohio in 1904, and which is now in general use; the introduction of the piston valves; and the very notable addition of the superheater by Schmidt, since greatly improved, drying out the steam and raising its temperature.

While the development of the locomotive has always been greatly retarded by limitations of space and wheel loads, that further great improvements are possible is very generally recognized. One of the most inviting is to reduce the expense of construction, and especially of maintenance, by reducing the number of parts.

The modern locomotive consist of some 15,000 separate and distinct pieces. Our high-pressure locomotive No. 1402 has friction points as follows: rolling 284, journal and pin 1,952, sliding 4,403, a total of 6,639. Of these, 2573 are manual operaton and 4,066 other than manual. Much labor is involved in keeping these in proper adjustment. When The Delaware and Hudson Railroad Corporation introduced the practice of casting the cylinders integral with the frame, we substituted

one piece for 834 pieces, and by installing in the 1403 the four drawn seamless steel drums for the conventional fabricated drums, we reduced the number of pieces to 660 and the dead weight by 5,750 pounds. The substitution of a welded boiler for the present built-up boiler would reduce the number of pieces by 2,492 and the dead weight by 4,750 pounds. Great opportunities still present themselves for eliminating seams, joints and rivets. Much of the material used may be improved by substituting for molten alloys the powdered metal alloys just now being developed.

The results The Delaware and Hudson Railroad Corporation have so far obtained in reducing fuel consumption in moving 1,000 tons (gross load) one mile on a 0.8 per cent grade are:

	Pounds
Standard Consolidation locomotive of 1913............	84.5
Boiler pressure raised to 275 pounds.......................	63.3
Boiler pressure raised to 350 pounds with water tubes in fire-box and compound cylinders.....................	48.8
Similar locomotive steam pressure 400 pounds.........	45.9
Similar locomotive steam pressure 500 pounds and heating feed water...	40.0

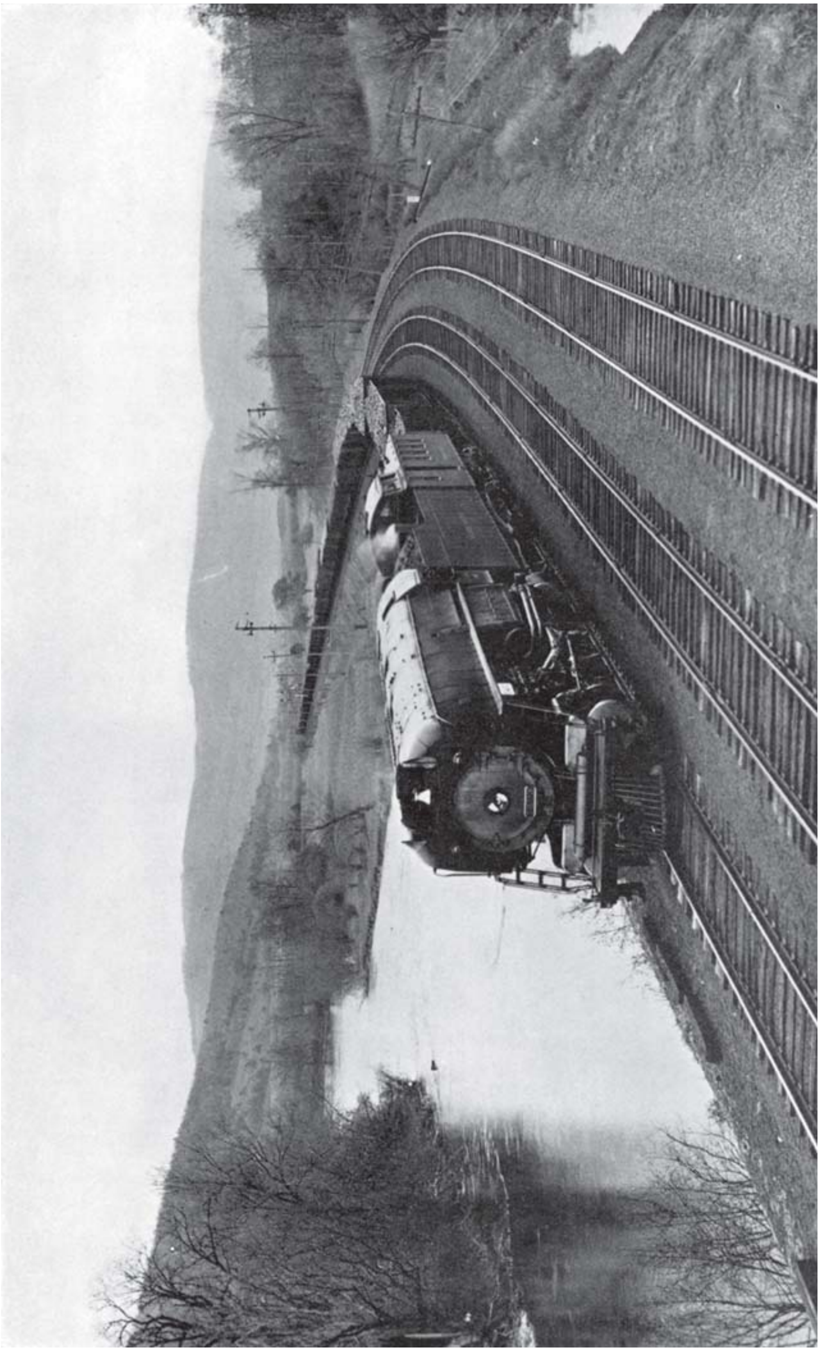
or a reduction of 53 per cent. With the further improvements now under way or in contemplation, we may hope to equal the achievements of the early years and reduce the fuel consumption of 1913 by at least 70 per cent.

The old engine had a thermal efficiency of about 4 per cent. Delaware and Hudson Railroad locomotive 1402 has a thermal

efficiency of 10 ½ per cent. It is believed that the new locomotive 1403 will have a thermal efficiency of 14½ per cent. This locomotive is equipped with poppet valves, roller bearings for the main driving axle, a feed water heater putting water into the boiler at 235 degrees, and is a triple expansion engine, the high-pressure cylinder carrying steam at 500 pounds, the intermediate cylinder at 290 pounds and the two low-pressure cylinders at 145 pounds, all working upon the same driving axle.

The Delaware and Hudson Railroad Corporation was the first to experiment with powdered fuel for locomotive use. We still hope to bring this to a successful conclusion, eliminating smoke and cinders, a greater utilization of the fuel potential, and reduction of the stand-by losses, at the same time having a fire-box that will burn either lignite or powered coal, or fuel oil, or a colloid of powdered coal and fuel oil.

It is felt that there is a good deal of promise in the waste gas economizer to raise still further the temperature of the boiler feed water; that the combustion air may be preheated, further increasing the thermal efficiency, and that a mechanical draft can be used, reducing the cylinder back pressure, as well as increasing the hauling capacity. Much may also be hoped for from the use of an improved type of superheater, raising the present limitation on temperature and increasing the boiler capacity, as well as avoiding the now very undesirable condition of the final passing of the superheated steam through the coldest part of the boiler, which removes a substantial portion of the heat that has been so expensively supplied.



The "L. F. LOREE" — *Built 1933*
by American Locomotive Company

SPECIFICATIONS

LOADED WEIGHT, driving	313,000 lb.
LOADED WEIGHT, leading	69,000 lb.
LOADED WEIGHT, engine	382,000 lb.
LOADED WEIGHT, tender	274,500 lb.
WHEEL BASE, driving	18' 10"
WHEEL BASE, engine	33' 9"
WHEEL BASE, engine and tender	83' 3 3/4"
CYLINDERS:	
1 H.P., 20" 1 I.P., 27 1/2"	2 L.P., 33"

DRIVING WHEEL DIAMETER	63"
BOILER PRESSURE	500 lb.
TUBES, length	15' 0"
TUBES, number and diameter	155—2"
TUBES, number and diameter	52—5 1/2"
HEATING SURFACE, tubes	1209 sq. ft.
HEATING SURFACE, flues	1116 sq. ft.
HEATING SURFACE, firebox	965 sq. ft.
HEATING SURFACE, arch tubes	61 sq. ft.

HEATING SURFACE, total	3351 sq. ft.
SUPERHEATING SURFACE	1076 sq. ft.
FIREBOX	139 15/16" x 78"
GRATE AREA	75.8 sq. ft.
TENDER CAPACITY, water	14,000 gals.
TENDER CAPACITY, coal	17 1/2 tons
MAXIMUM TRACTIVE POWER:	
Simple	90,000
Triple Expansion	75,000
Tender Booster	18,000

These improvements would add:

Preheated air	0.5%
Pulverized fuel	1.0%
Waste gas economizer	0.5%
Increased temperature in superheater	1.0%
Mechanical draft	0.5%

or an improvement in sight to recovery of 18 per cent. Even with this realization, we would still be behind the modern central power stations, which, at the present time develop a thermal efficiency of 25 per cent.